sary in kitchen and laundry for proper vapor control and for the reduction of peaks in relative humidity which would otherwise occur in those areas.

3. *Ventilation of Structure.* The third measure listed for the control of concealed condensation, ventilation of the structure itself, is effective in certain cases especially as a supplement to warm side vapor resistance which is considerable but not of itself fully adequate. Air from outside is used. The vents must be shielded from the entrance of rain and insects.

Attics and crawl spaces may be considered as parts of the structure, and for these portions ventilation is practically a necessity. Attic ventilation has long been an established practice but its effectiveness is likely to be diminished by the newer practice of adding insulation to ceilings. Insulation requires added ventilation which in turn necessitates adequate insulation. The recommended ventilation shown in Table 3 for dwellings[14] is based on such insulation. The *net area* refers to the total of all openings free from obstructions. The use of louvers and 8-mesh screen (usually recommended) requires a gross area 2.25 times that listed. In Zone I of Fig. 6 a ceiling vapor barrier is recommended for all constructions. It is also necessary that stray openings from walls into the attic, or around a loose fitting attic door be avoided. The *stack effect* allows a large inflow of warm air from the dwelling, transporting much vapor to a danger area. More desirable ventilation of the house can be arranged.

Crawl spaces under dwellings where the earth is damp and uncovered require a high rate of ventilation. At least four openings, one at each corner, as high as possible, should be provided.[14] Their total net area may be calculated by the formula:

$$a = \frac{2L}{100} + \frac{A}{300} \qquad (10)$$

where:

L = the perimeter of the crawl space, linear ft.

A = the area of the crawl space, square feet.

a = the total net area of all vents, (or the gross area if a 4-mesh screen is used) square feet.

This ventilation is usually sufficient but cools the first floor so much that insulation is needed. A better treatment is a cover on the damp ground. This cover may be a concrete slab, or merely heavy roll roofing laid on a graded surface with its edges lapped 2 in. (but not necessarily cemented). With this barrier, the vent area may be reduced to 10 percent of that calculated by Equation 10.

In building walls, cavity ventilation can be applied in a moderate climate as the sole vapor control system. In general, however, air passages in walls designed to remove an unrestricted vapor supply are unduly large and may waste considerable heat. On the other hand, a barrier as the only control measure would, in some cases, require so high a resistance as to be impractical. Ventilation of the structure in conjunction with a vapor barrier, is a procedure with important applications, but its general utility has not been fully investigated. Ventilation is most effective when each structural space has a clearly defined air passage with an inlet and outlet. In walls a small thermosyphon effect may be utilized by locating one vent at the bottom and one at the top of each space.

The best time to vapor-proof a building is during its construction. After a building is completed, ventilation of the occupied space is the most easily applied of the three basic control measures. Paint that is chosen for its low vapor permeance can be applied as a barrier on the interior with good results, care being taken that all areas, including parts of partitions and ceilings which offer an indirect vapor path to the cold wall, are covered. Ventilation of the wall cavity is effective in certain cases especially to supplement the foregoing measures. When such venting is required, each cavity space isolated by framing should be separately vented with an inlet and outlet judiciously placed, to accomplish proper air change.

CONDENSATION IN COOLED STRUCTURES

Water vapor is sometimes an even greater problem in cooled structures than in those which are heated, but the basic facts of its migration and condensation on cold surfaces are the same. Refrigerators, cold pipes and cold vessels all require insulation and should be provided with a vapor barrier. The barrier, as always, should be placed on the warm side of the insulation and as close as possible to the warm surface of any enclosure. It resists the movement of water vapor toward the colder parts of the structure, and its job is even more exacting than that required in residential construction. In the case of an insulated cold pipe line, the process is likely to be uninterrupted for years and there is no chance for vapor that enters the insulation to dry out periodically. Also, no vapor can escape from the cold side, if this is a metal (vapor tight) pipe. For such an application vapor control requires insulating material that is itself very highly resistant to water vapor or a coating whose permeance is the minimum obtainable, not over 0.1 perm. Metal coverings are desirable but difficult to apply.

Similar considerations apply in the case of cold rooms whether constructed inside a heated building or as a separate building. In the latter case, cold rooms operating above freezing provide some periods of vapor reversal in winter but such drying can be of little help. Refrigerators, however, if lined with cement or other vapor permeant material, will allow slight amounts of vapor to pass and to that extent reduce the accumulation of moisture that may have penetrated the barrier. While this is helpful, emphasis must be placed on an adequate warm side barrier not greater than 0.1 perm.

Summer air cooling for comfort does not involve serious vapor problems and vapor control measures are not essential. Normally the cooled air is little, if any, colder than the dew-point temperature of the outside atmosphere and there are no areas of condensation. However, the interior vapor pressure is often below that outside and therefore, vapor, which diffuses inward, adds to the cooling load. Vapor barriers in walls installed for winter needs, are a help in reducing this element of the cooling load.

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